DECLARATION

I, Sungwon Han, of 4th floor, Leader's Tower, 836-70 Yeoksam-dong, Gangnam gu, Seoul, Korea, do hereby declare that:

1) I am conversant with the English and Korean languages and am a competent translator therebetween;

2) To the best of my knowledge and belief, the attached is a true and correct translation of the priority applications No. 31567/1999 for the United States Patent Application No. 10/705,899.

Signed this 8th day of July, 2008

Sungwon Han

[ABSTRACT]

Disclosed is a multi-domain liquid crystal display element that can realize a multi-domain using a gate line.

According to the present invention, the multi-domain liquid crystal display element includes a data line to which a data signal is applied, a gate line formed intersecting the data line and receiving a gate signal, a pixel electrode for driving liquid crystal, a switching element formed at an intersection region and connected to the pixel electrode, and a sub-electrode line extending from the gate line in a vertical direction to adjust together with the gate line an alignment direction of the liquid crystal.

According to the present invention, by using the gate line as the sub-electrode line, an aperture ratio can be improved and the resistance component is reduced, thereby improving the luminance non-uniformity caused by a voltage difference, flicker and afterimage phenomenon can be improved.

[REPRESENTATIVE DRAWING]

FIG. 4

[SPECIFICATION]

[TITLE OF THE INVENTION]

MULTI-DOMAIN LIQUID CRYSTAL DISPLAY ELEMENT

[BRIEF DESCRIPTION OF THE DRAWINGS]

FIG.1 is a top plan view of a multi-domain liquid crystal display element according to the related art.

FIG. 2 is a top plan view of another multi-domain liquid crystal display element.

FIG. 3 is a cross-sectional view taken along line A-A' of FIG. 2.

FIG. 4 is a top plan view of a multi-domain liquid crystal display element according to an embodiment of the present invention.

FIG. 5 is a waveform of a signal supplied from a gate line of FIG. 4.

FIG. 6a to 6g are views illustrating a variety of dielectric structures or slits that can be applied to a pixel region for realizing a multi-domain.

<DESCRIPTION OF THE SYMBOLS IN MAIN PORTIONS OF THE DRAWINGS>

2: Data line	4: Gate line
6: Thin film transistor	8: Source electrode
10: Drain electrode	11: Drain contact
12: Gate electrode	14, 24, 28: Gate dielectric
16, 22, 24: Sub-electrode line	26: Gate dielectric
30: Black matrix	32: Color filter
34: Common electrode	35: Open region of common electrode
36: Liquid crystal layer	

[DETAILED DESCRIPTION OF THE PRESENT INVENTION]

[OBJECT OF THE PRESENT INVENTION]

[FIELD OF THE INVENTION AND DESCRIPTION OF THE RELATED ART]

The present invention relates to a liquid crystal display device, and more particularly, to a multi-domain liquid crystal display element that can realize a multi-domain using a gate line.

Generally, a liquid crystal display device displays an image by adjusting light transmittance of liquid crystal cells in accordance with video signals. While the liquid crystal display device advantages of being manufactured to be small and thin and using low power consumption, it has a disadvantage of having a narrow viewing angle. Among the liquid crystal display devices, an active matrix type liquid crystal display providing switching elements for the respective liquid crystal cells is more proper for displaying motion pictures. In the active matrix type liquid crystal display, a thin film transistor is usually used as the switching element.

The active matrix type liquid crystal display device displays an image corresponding to the video signals such as television signals on picture elements or pixels arranged on intersecting portions of the gate lines and the data lines. Each of the pixels includes a liquid crystal cell that adjusts the light transmittance in accordance with a voltage level of data signals from the data lines. The thin film transistors are installed on the respective intersecting portions between the gate lines and the data lines to switch the data signals that will be transferred to the liquid crystal cells in response to scan signals from the gate lines.

In recent years, in order to compensate for the narrow viewing angle of the liquid crystal display device, a scheme for adjusting alignment directions of the liquid crystals in different directions at each of at least two sub-regions that are divided in each of the pixels has been proposed. Such a liquid crystal display device includes a multi-domain liquid crystal display element in which sub-electrode lines are formed around pixel electrodes. The multi-domain liquid crystal display element drives liquid crystals using the sub-electrodes electrically insulated from the pixel electrodes without aligning the liquid crystals.

Referring to FIG. 1, there is shown a cross-sectional view of a unit pixel provided in a related art multi-domain liquid crystal display element. A unit pixel includes first and second substrates, a plurality of data and gate lines that are

longitudinally and latitudinally formed on the first substrate to divide the first substrate into a plurality of pixel regions, a plurality of thin film transistors that are respectively formed the pixel regions on the first substrate and each of which includes a gate electrode, a gate dielectric, a semiconductor layer, an ohmic contact layer, and source/drain electrodes, a passivation layer 26 formed on an entire surface of the first substrate, a pixel electrode 28 formed on the passivation layer 26 and connected to the drain electrode, and a sub-electrode 21 formed on the gate dielectric and partly overlapping the pixel electrode 28. In addition, the unit pixel further includes a black matrix 30 that is formed on the second substrate to block light leaking from the gate lines, data lines, and thin film transistors, a color filter 32 formed between the black matrix in response to the pixel regions, a common electrode formed on the black matrix 30 and color filter 34, and a liquid crystal layer 36 between the first and second substrates. The sub-electrode 24 formed around the pixel electrodes 28 and the open region of the common electrode 34 distort the electric field applied to the liquid crystal layer 36 to variously drive the liquid crystal molecules in the unit pixel. That is, when the voltage is applied to the liquid crystal display element, the dielectric energy is aligned in a desired direction by the electric field that is distorted. In this case, the liquid crystal display element requires the open region 35 formed on the common electrode to obtain a multi-domain effect. If no open region 35 is formed on the common electrode 34 or the open region 35 is narrow, the degree to which the electric field required for dividing a domain is distorted is low, a time for which the directors of the liquid crystal molecules become stable increases.

However, in the liquid crystal display element, when the sub-electrode 24 enclosing edges of the pixel electrodes 28 is used to realize the multi-domain, an aperture ratio proportional to a size of the pixel electrode 28 is reduced. As a result, the luminance of the liquid crystal display element is deteriorated. In addition, in FIG. 1, the sub-electrode 24 is formed on a same plane as the data line. In this case, there may be a circuit-short between the data line and the sub-electrode 24. When there is a circuit-short between the data line and the sub-electrode 24, the line coupling occurs in the data direction. To prevent this, a sufficient distance between

the data line and the sub-electrode 24 must be attained. As a result, since the size of the pixel electrode 26 is further reduced, the aperture ratio is further reduced. In addition, the related art sub-electrode 24 is provided in the form of a line type and a width of the sub-electrode 24 is formed as narrow as possible (e.g., 6μm) considering the aperture ratio, i.e., the size of the pixel electrode 26 and the resistant value increases. As the resistance value of the sub-electrode 24 increases, a voltage difference increases by the resistance component of the sub-electrode when it is applied to the large-sized panel. Particularly, when the common voltages is applied to the sub-electrode 24 at both side portions of the panel, the voltage difference increases as the resistance value of the sub-electrode 24 increases as it goes inside the panel. As a result, a potential difference between the pixel electrode 26 and the sub-electrode 24 varies for the liquid crystal cells, the luminance is not uniform and a flicker, afterimage, and the like are generated, thereby deteriorating the image quality.

Referring to FIG. 2, there is shown a top plan view of a multi-domain liquid crystal display element disclosed in Korean Patent Application No. 99-05587 filed by the applicant of this application. In FIG. 2, the multi-domain liquid crystal display element includes a thin film transistor 6 located at an intersection region of a data line 2 and a gate line 4, a pixel electrode 14 coupled to a drain electrode 10 of the thin film transistor 6, and a sub-electrode 16 formed around the pixel electrode 14. The thin film transistor 6 is formed at the intersection region of the data line 2 and the gate line 4. The thin film transistor 6 includes a gate electrode 12 connected to the gate line 4, a source electrode 8 connected to the data line 2, and the drain electrode 10 connected to the pixel electrode 14 through a drain contact 11. In addition, the thin film transistor 6 further includes a semiconductor layer (not shown) for forming a conductive channel between the source electrode 8 and the drain electrode 10 using the gate voltage applied to the gate electrode 12. Such a thin film transistor 6 selectively supplies a data signal from the data line 2 to the pixel electrode 14 in response to the gate signal from the gate line 4. The pixel electrode 14 is located at a cell region divided by the data line 2 and the gate line 4 and is formed of an indium tin oxide material having an excellent light transmittance. The pixel electrode 14

generates a potential difference relative to a transparent electrode (not shown) formed on an upper glass substrate by the data signal supplied via the drain contact 11. At this point, the liquid crystal twits by dielectric anisotropy and allows the light supplied from a light source via the pixel electrode 14 to transmit the upper glass substrate. The sub-electrode line 16 generates the potential difference relative to the pixel electrode 14 during a scanning period for which the data signal is applied to the liquid crystal cell to adjust the alignment direction of the liquid crystal, thereby realizing the multi-domain. In this case, a common voltage Vcom is applied from a common voltage generation circuit to the sub-electrode line 16. In addition, the black matrix formed on the upper glass substrate is designed such that a boundary line 15 of the black matrix is located above the sub-electrode line 16 so that the black matrix can partly cover the sub-electrode 16.

However, in the liquid crystal display element, when the sub-electrode one 16 enclosing edges of the pixel electrodes 14 is used to realize the multi-domain, an aperture ratio proportional to a size of the pixel electrode 14 is reduced. As a result, the luminance of the liquid crystal display element is deteriorated. In addition, as shown FIG. 3, the sub-electrode line 16 is formed on a same plane as the gate line 14. In this case, there may be a circuit-short between the gate line 4 and the sub-electrode 16. When there is a circuit-short between the gate line 4 and the sub-electrode 16, the line coupling occurs in the gate direction. To prevent this, a sufficient distance d between the data line and the sub-electrode 24 must be attained. As a result, since the size of the pixel electrode 14 is further reduced, the aperture ratio is further reduced. In addition, the related art sub-electrode line 16 is provided in the form of a line type and a width of the sub-electrode line 16 is formed as narrow as possible (e.g., 6μm) considering the aperture ratio, i.e., the size of the pixel electrode 14 and the resistant value increases. As the resistance value of the sub-electrode line 16 increases, a voltage difference increases by the resistance component of the sub-electrode when it is applied to the large-sized panel. Particularly, when the common voltages is applied to the sub-electrode line 16 at both side portions of the panel, the voltage difference increases as the resistance

value of the sub-electrode line 16 increases as it goes inside the panel. As a result, a potential difference between the pixel electrode 14 and the sub-electrode line 16 varies for the liquid crystal cells, the luminance is not uniform and a flicker, afterimage, and the like are generated, thereby deteriorating the image quality.

[TECHNICAL OBJECT OF THE INVENTION]

It is therefore an object of the present invention to provide a multi-domain liquid crystal display element that is designed to increase an aperture ratio by using a gate line as a sub-electrode and a method of fabricating the liquid crystal display element.

It is another object of the present invention to provide a multi-domain liquid crystal display element that is designed to prevent a circuit-short a data line or a gate line and a sub-electrode line by using a gate line as a sub-electrode line.

It is still another object of the present invention to provide a multi-domain liquid crystal display element that is designed to improve a luminance non-uniformity, flicker, afterimage phenomenon by reducing a resistance of a sub-electrode line by using a gate line as the sub-electrode line.

[CONSTITUTION AND OPERATION OF THE INVENTION]

In order to achieve the objects, a multi-domain liquid crystal display element of the present invention a data line to which a data signal is applied, a gate line formed intersecting the data line and receiving a gate signal, a pixel electrode for driving liquid crystal, a switching element formed at an intersection region and connected to the pixel electrode, and a sub-electrode line extending from the gate line in a vertical direction to adjust together with the gate line an alignment direction of the liquid crystal.

It is noted that the appending drawings illustrating preferred embodiments and descriptions thereof should be referred to adequately to appreciate the advantages in every aspect oft eh inventive devise and the purposes accomplished by the implementation of the present invention.

The present invention now will be described more fully hereinafter with reference to FIGS. 4 to 6g, in which preferred embodiments of the invention are shown.

FIG. 4 is a top plan view of a multi-domain liquid crystal display element according to an embodiment of the present invention. A multi-domain liquid crystal display element of FIG. 4 has a sub-electrode line 22 extending from a gate line 4 while the multi-domain liquid crystal display element of FIG. 2 has a sub-electrode line 16 independent from a gate line 4, except for which other parts are same as those of FIG. 2.

A thin film transistor 6 formed at an intersection region of a data line 2 and a gate line 4 selectively supplies a data signal from the data line 2 to a pixel electrode 24 in response to a gat signal from the gate line 4. The thin film transistor 10 includes a gate electrode 12 connected to the gate line 4, a source electrode 8 connected to the data line 2, and a drain electrode 10 connected to the pixel electrode through a drain contact 11. In addition, the thin film transistor 6 further includes a semiconductor layer (not shown) for forming a conductive channel between the source electrode 8 and the drain electrode 10 using the gate voltage applied to the gate electrode 12. The pixel electrode 24 is located at a cell region divided by the data line 2 and the gate line 4 and is formed of an indium tin oxide material having an excellent light transmittance. The pixel electrode 24 generates a potential difference relative to a transparent electrode (not shown) formed on an upper glass substrate by the data signal supplied via the drain contact 11 to drive the liquid crystal. The sub-electrode line 22 is formed extending from the gate line 4 in a vertical direction, i.e., an up-down direction of the gate line 4, being located between the data line 2 and the pixel electrode 24. The sub-electrode line 22 together with the gate line 4 formed around the pixel electrode 24 adjusts an alignment direction of the liquid crystal using a potential difference relative to the pixel electrode 24. In this case, the sub-electrode line 22 realizes the multi-domain using the gate signal applied to the gate line 4. This is generally enabled by applying a gate low voltage Vgl for most of the time of a one frame period (e.g.,

16.67ms) as shown in FIG. 5. In addition, a high state gate voltage Vg (e.g., 20V) that is applied by one time for each gate line 4 for the one frame period (i.e., 16.67ms) is applied for 1/1000 (e.g., 15.6μs) of the one frame, it rarely affects on realizing the multi-domain.

The following will describe a method of fabricating the above-described multi-domain liquid crystal display element according to the present invention.

First, the thin film transistor 6 having the gate electrode 12, gate dielectric, semiconductor layer, ohmic contact layer, and source and drain electrodes 8 and 10 is first formed on the pixel region of a first substrate. At this point, a plurality of the gate lines 4, a plurality of the data lines 2, and a plurality of the sub-electrode line 22 are formed to form a plurality of the pixel regions.

In more detail, the gate electrodes 12 and the gate lines 4 are formed by applying and patterning a single or dual-layer formed of Al, Mo, Cr, Ta, or Al alloy through a sputtering process and, as the same time, the sub-electrode line 22 is formed with openings corresponding to the gate lines 44. Here, when the sub-electrode lines 22 are formed of a same material as the gate lines 4, the sub-electrode lines 22 are formed as the same plane as the gate lines 4 using a same mask so that the sub-electrode lines 22 can be electrically connected to the common electrode formed above thereof. In addition, the sub-electrode lines 22 may be formed of a different material from the gate line 4 using a different mask and a different material. The sub-electrode lines 22 may be formed with a dual-layer using different metal materials. The gate dielectric formed of SiNx or SiOx is formed above the resulting structure through a plasma enhanced chemical vapor deposition (PEDVD) process and patterned. Subsequently, the semiconductor layer and the ohmic contact layer are formed by respectively applying a-Si and N+a-Si through the PECVD process. Alternatively, the gate dielectric, a-Si, and N+a-Si are continuously deposited through the PECVD process to form the gate dielectric and patterned to form the semiconductor layer and the ohmic contact layer. In addition, metal such as Al, Mo, Cr, Ta, or Al alloy are applied through the sputtering process and patterned to form the data lines 2 and the source and drain electrodes 8 and 10.

Next, a passivation layer is formed by applying benzocyclobutene (BCB), acrylic resin, polyimide composition, SiNx, SiOx, or the like on an entire surface of the first substrate and an indium thin oxide material is applied through the sputtering process and patterned to form the pixel electrodes.

The black matrix is formed on a second substrate separately provided, after which a color filter layer is formed such that red, green, and blue elements are repeatedly formed for the respective pixels. A photoresist material is applied on the color filter later, after which the photoresist material is patterned through a photolithography process to form dielectric structures having a variety of different shapes as shown in FIGS. 6a to 6g. In addition, a common electrode of an upper substrate that will be formed after the dielectric structure is patterned to form open regions (i.e., slits) of the common electrode. The variety of different shapes are shown in FIGS. 6a to 6g. Next, like the pixel electrode 24, the common electrode is formed as a transparent electrode using the indium tin oxide or the like. Subsequently, by injecting liquid crystal between the first and second substrates, the multi-domain liquid crystal display element is completed. In this case, the liquid crystal defining the liquid crystal layer is positive or negative anisotropic liquid crystal and may contain chiral dopants. The material for forming the dielectric structure may has a same permittivity (e.g., 3 or less) as the liquid crystal material. As a material for the dielectric structure may be photoacrylate or BCB. The dielectric structure may be formed above the common electrode.

Further, the multi-domain liquid crystal display element of the present invention further includes a phase difference film that is formed on one of the first and second substrates by elongating polymer material. The phase difference film is a negative uniaxial film. That is, the phase difference film is formed of a uniaxial film having one optical axis. The phase difference film functions to compensate for a direction the user feels in a direction caused by a variation of a viewing angle and a vertical direction of the substrate. Therefore, an area where no gray inversion exists is enlarged and a contrast ratio in an inclined direction increases. In addition, by forming one pixel with a multi-domain, the viewing angle in left and right direction can

be more effectively compensated for. The phase difference film may be also formed of a negative biaxial film in addition to the negative uniaxial film. The negative biaxial film having two optical axes can provide a wider viewing angle than the uniaxial film. After applying the phase difference film as described above, polarizer is attached on each of the first and second substrates. In this case, the polarizer may be attached in a state where it is integrally formed with the phase difference film.

As described above, the multi-domain liquid crystal display element according to the present invention extending line portions 22 from the gate lines 4 are used as the sub-electrode lines, the size of the pixel electrode 24 can increase. In addition, the line defect of the related art, which is caused by the short-circuit problem between the sub-electrode line that is formed independent from the gate line and is applied with the common voltage Vcom and the data line or the gate line can be prevented. In addition, since the sub-electrode line 22 can realize the multi-domain using a gate low voltage supplied to the gate line 4, the common voltage is not necessary. Further, since the gate line 4 having a greater width (e.g., 20μm) than the related art sub-electrode is used as the sub-electrode line, the resistance component of the sub-electrode line can be reduced. By the reduction in the resistance component, the voltage different at the sub-electrode line can be reduced and thus the luminance non-uniformity, flicker, afterimage phenomenon can be improved.

[EFFECT OF THE INVENTION]

As described previously, since the multi-domain liquid crystal display element according to the present invention uses the gate line as the sub-electrode line, the size of the pixel electrode increases and thus the aperture ratio can increase. Therefore, the luminance of the liquid crystal display element can be improved. In addition, in the multi-domain liquid crystal display element according to the present invention, the line defect of the related art, which is caused by the short-circuit problem between the sub-electrode line that is formed independent from the gate line and is applied with the common voltage Vcom and the data line or the gate line can

be prevented. In addition, since the sub-electrode line 22 can realize the multi-domain using a gate low voltage supplied to the gate line 4, the common voltage is not necessary. Further, since the gate line 4 having a greater width (e.g., 20μm) than the related art sub-electrode is used as the sub-electrode line, the resistance component of the sub-electrode line can be reduced. By the reduction in the resistance component, the voltage different at the sub-electrode line can be reduced and thus the luminance non-uniformity, flicker, afterimage phenomenon can be improved.

WHAT IS CLAIMED IS:

1. A multi-domain liquid crystal display element comprising:

a data line to which a data signal is applied;

a gate line formed intersecting the data line and receiving a gate signal;

a pixel electrode for driving liquid crystal;

a switching element formed at an intersection region and connected to the pixel electrode; and

a sub-electrode line extending from the gate line in a vertical direction to adjust together with the gate line an alignment direction of the liquid crystal.

2. The multi-domain liquid crystal display element according to claim 1, wherein the sub-electrode line is formed between the data line formed around the pixel electrode and the pixel electrode.

[DRAWINGS]

Fig. 1

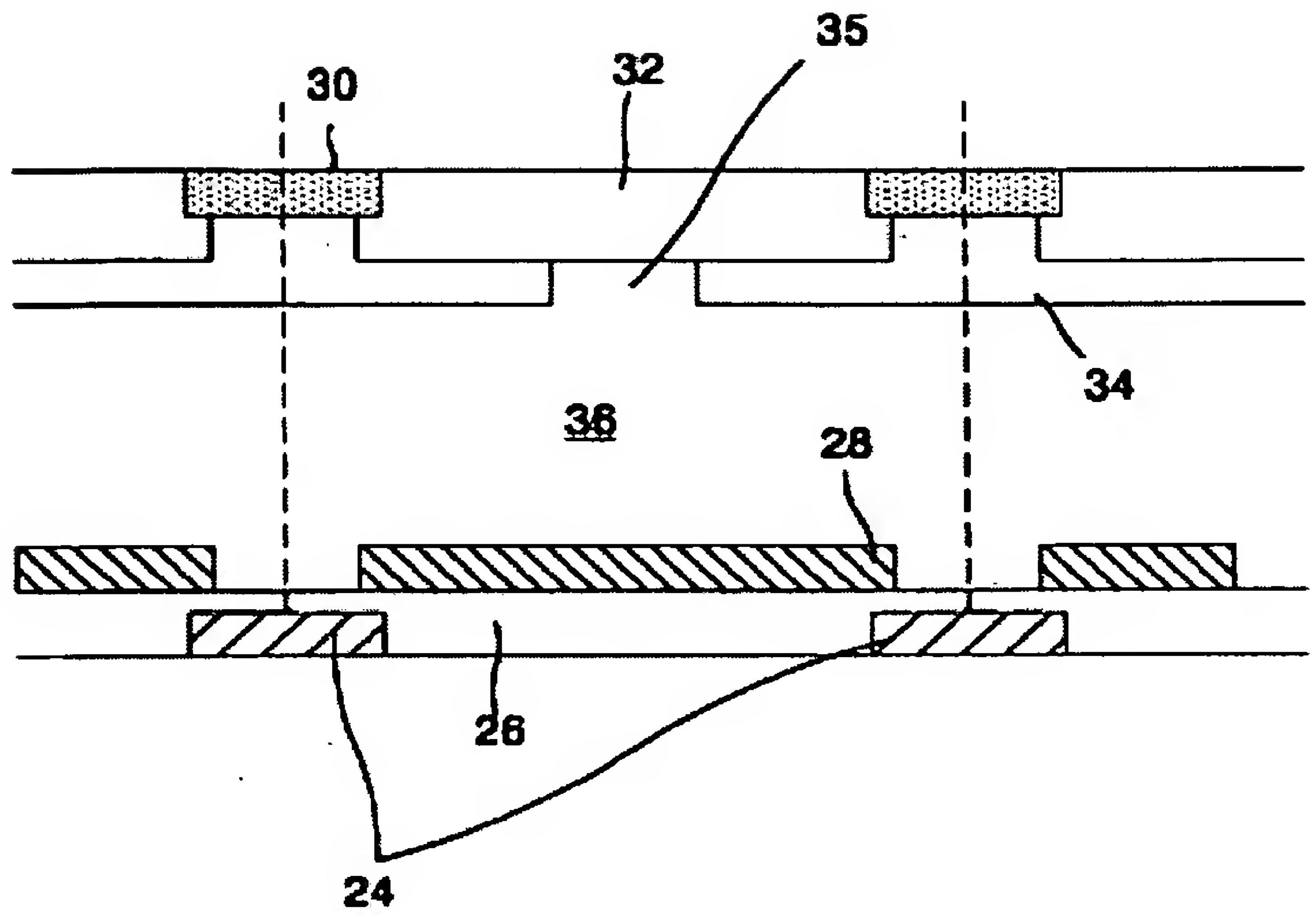


Fig. 2

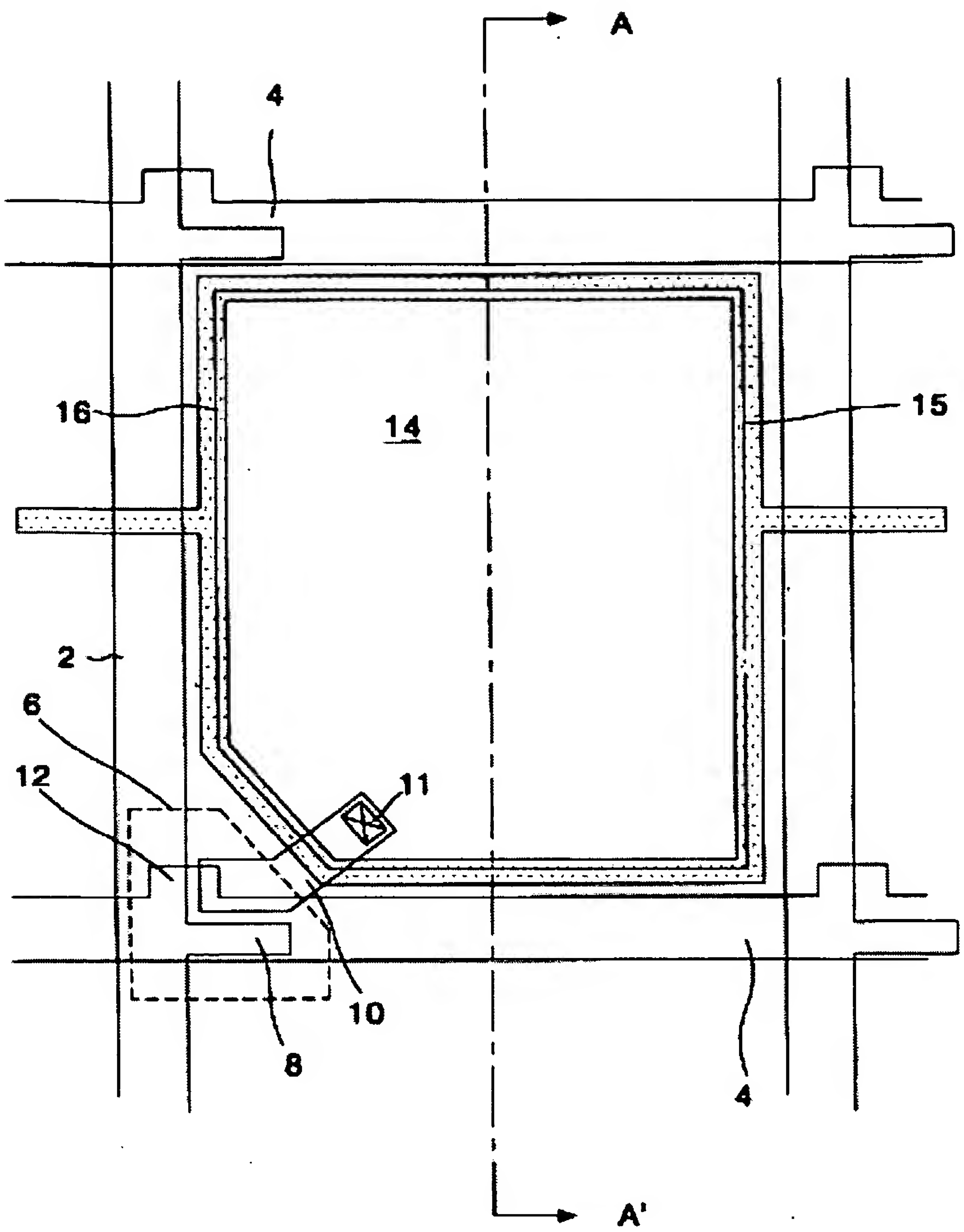


Fig. 3

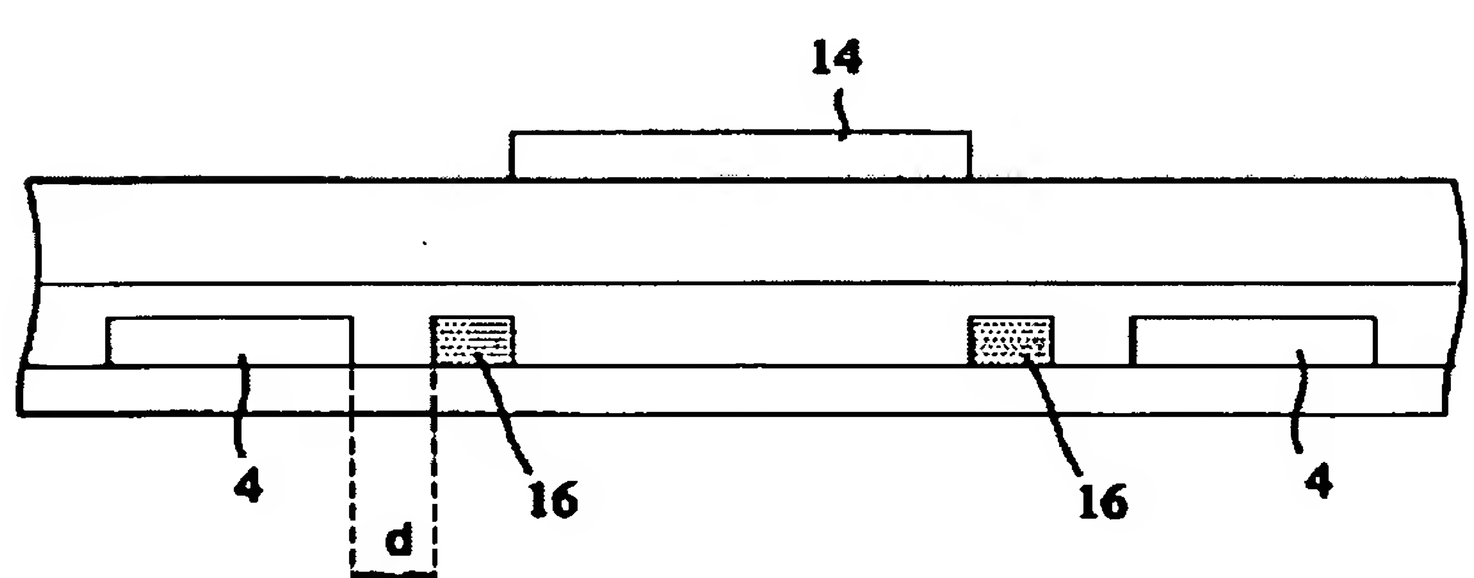


Fig. 4

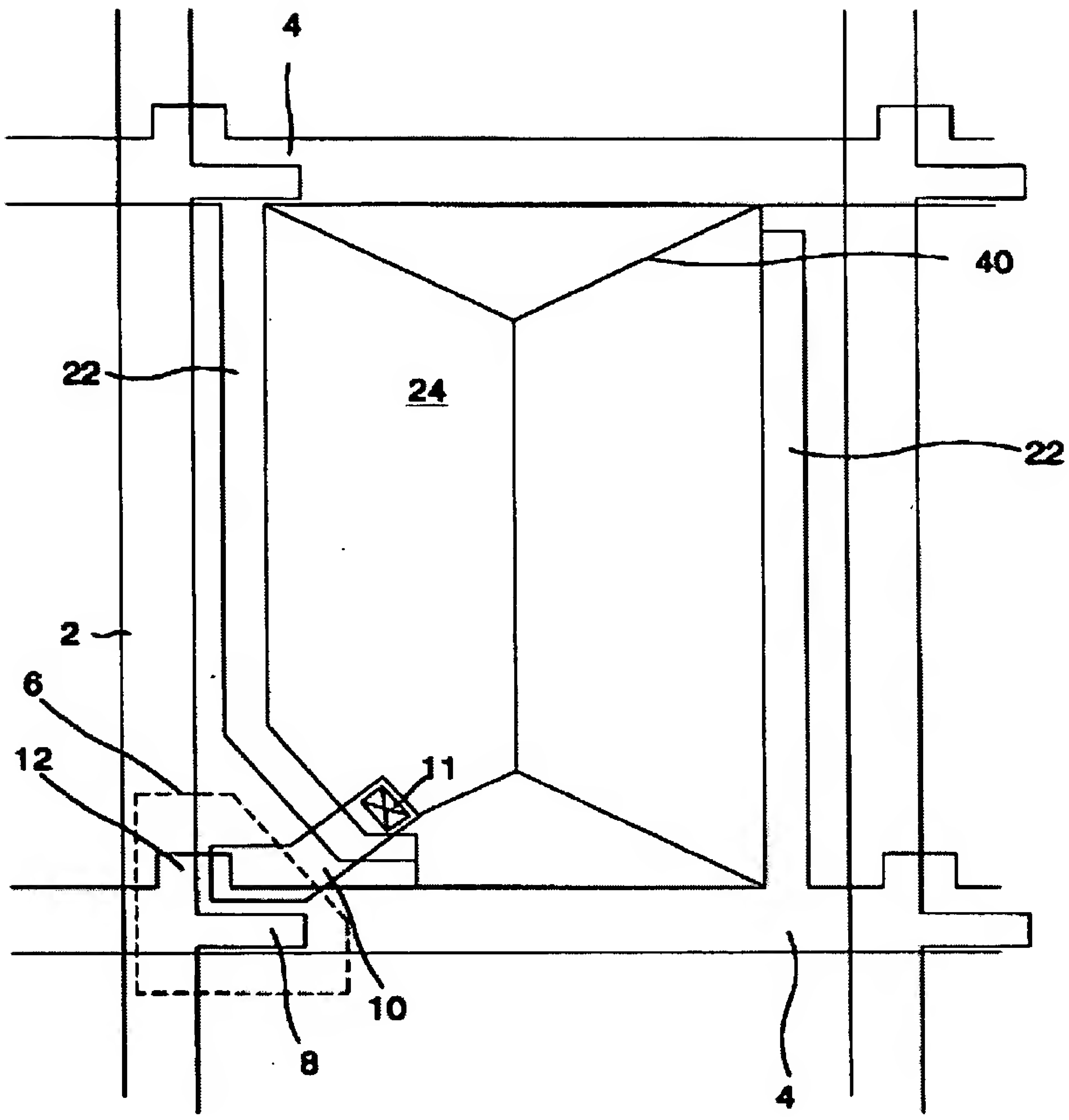


Fig. 5

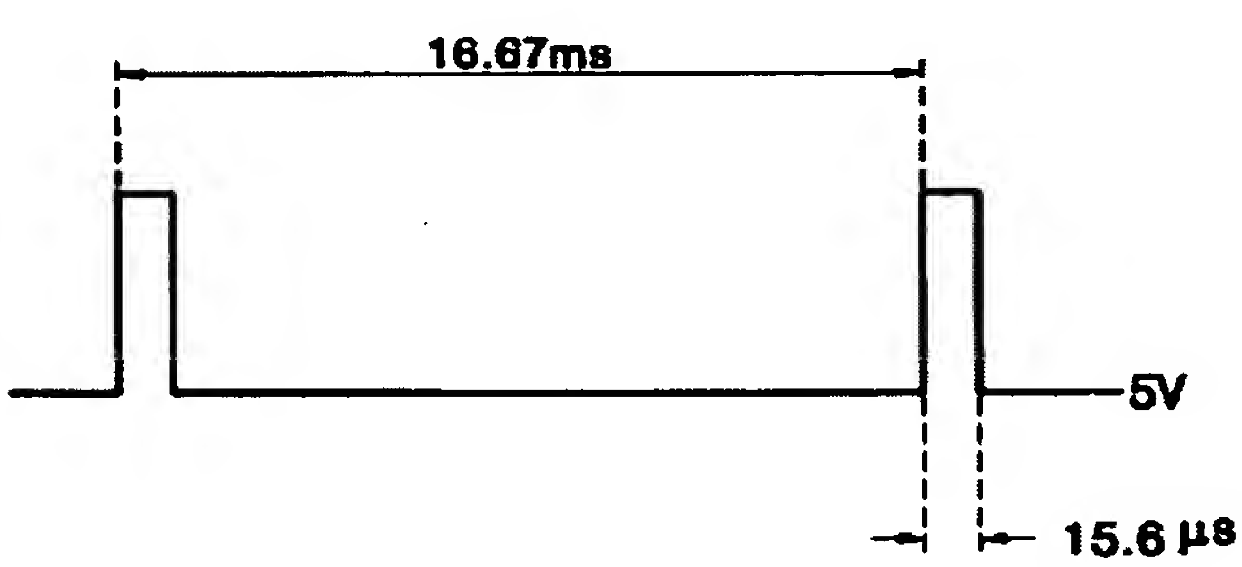


Fig. 6a

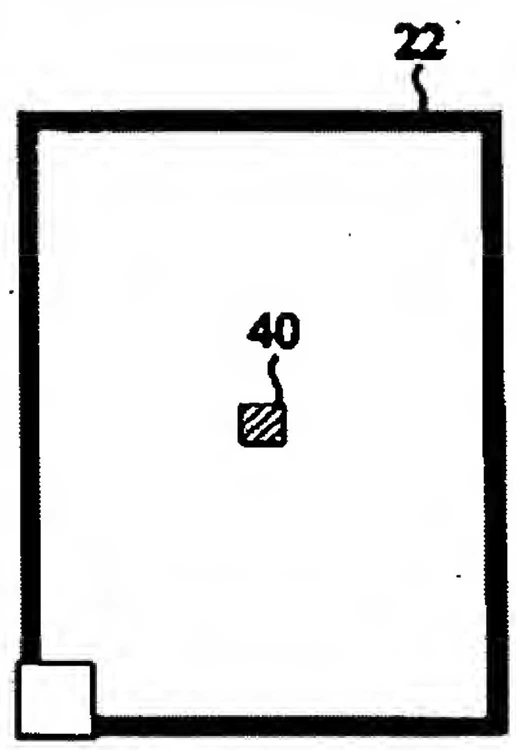


Fig. 6b

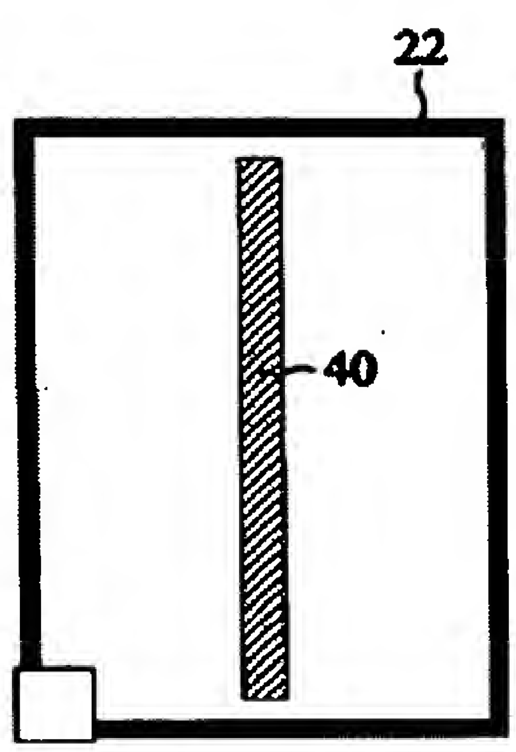


Fig. 6c

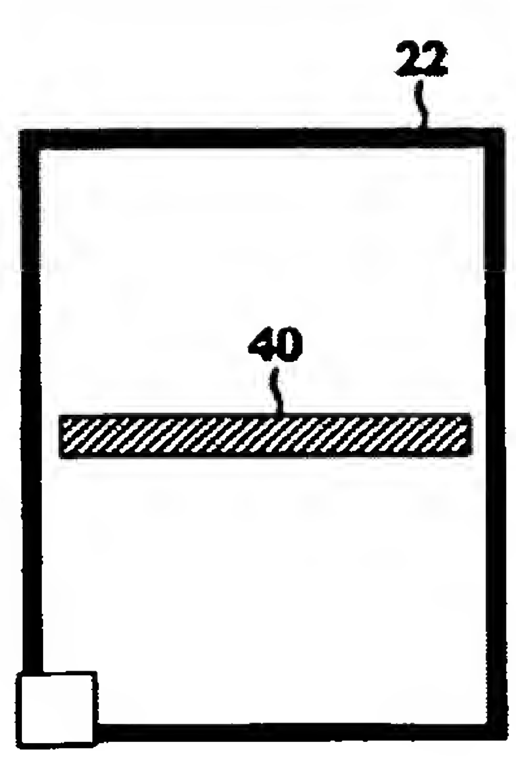


Fig. 6d

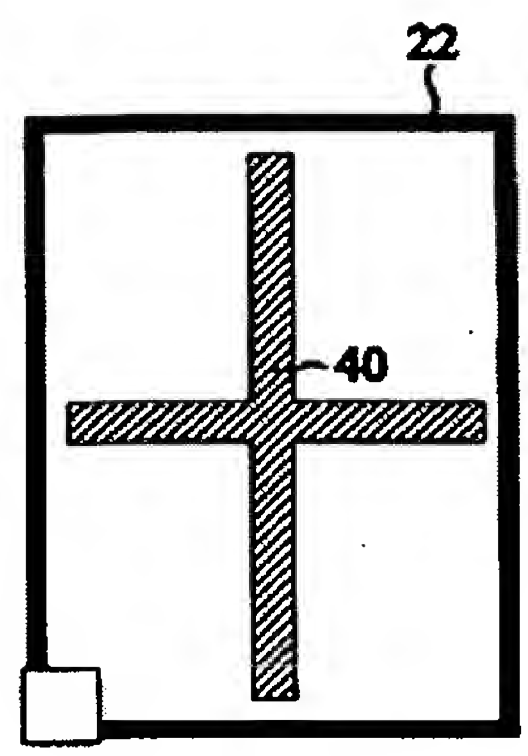


Fig. 6e

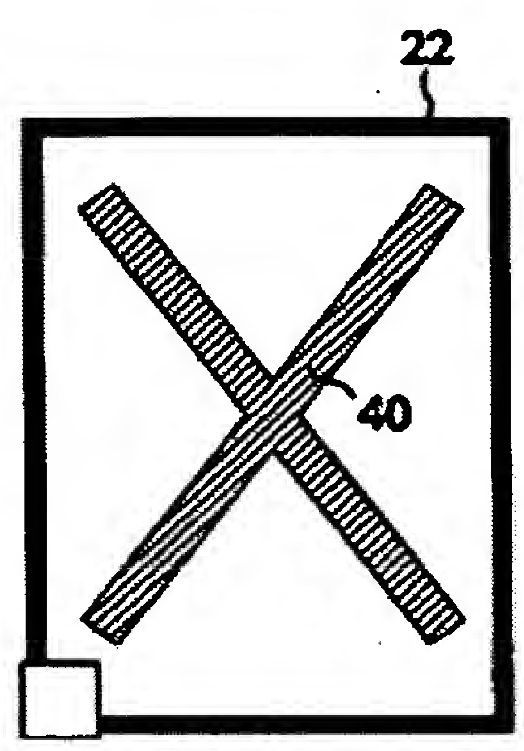


Fig. 6f

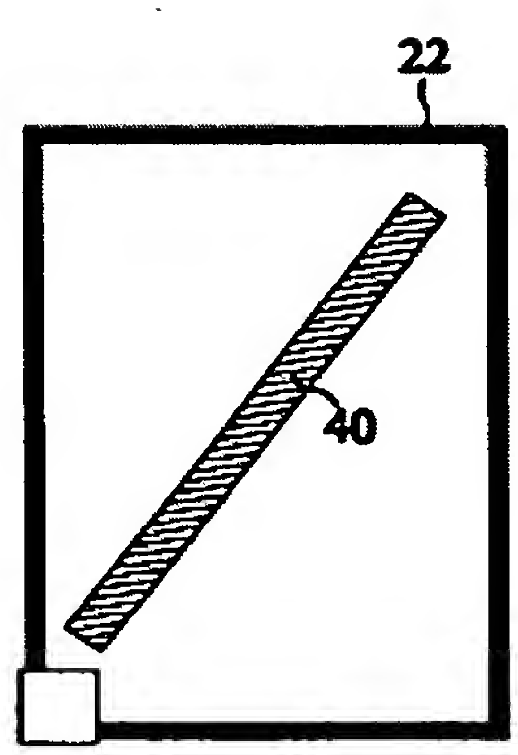
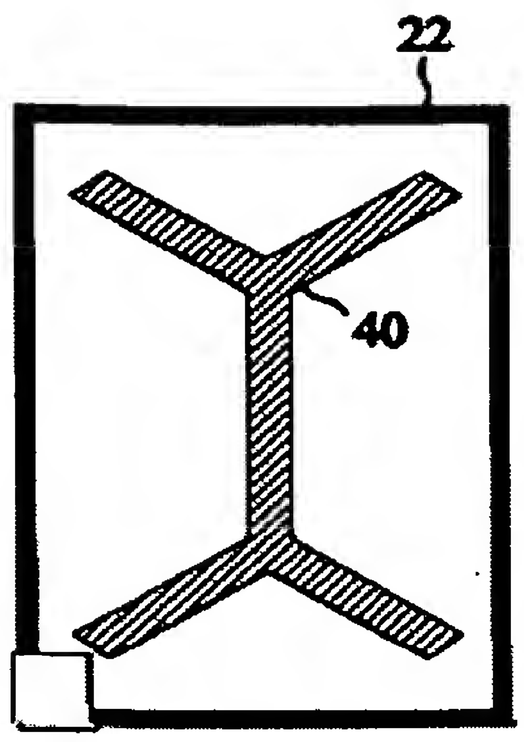


Fig. 6g


22
40